Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.17, 2014
www.iiste.org

Characterization from Geochemical Analysis of Ditch-Cuttings from Agbada Formation, Warri North Area, Southern Niger Delta, Nigeria

Jayeola, A.O.
Department of Earth Sciences, Adekunle Ajasin University, P.M.B 001, Akungba Akoko, Ondo state, Nigeria
Correspondence Author's email: jaffero2001@yahoo.com

Abstract
Recoverable ditch cuttings from a well in OML 40 in the Warri North area of Southern Niger Delta were subjected to geochemical analysis to determine the TOC and SOM values. The TOC values varied from 1.70w% - 1.90w% with an average of 1.76w%, while the SOM values ranged from 0.019% - 2.85% with an average of 0.562%. The above results show that the TOC values fall above the minimum threshold for hydrocarbon generation potential. The minimum threshold value for TOC in the Niger Delta is 0.5%. The average SOM value of 0.562% is also indicative of good source rock potential for the studied samples. The transformation ratio which serves as a quantitative analysis to determine the level of maturity shows an average value of 0.29 against the minimum threshold value of 0.16. Therefore, it can be implied that the sediments from the studied depth slice can be regarded as good source rock for hydrocarbon generation.
Keywords: Geochemical, hydrocarbon, maturity, threshold.

Introduction

The formation of crude oil and its associated gas are globally believed to have been formed when the remains of dead animals and plants are mixed with sediments, buried and formed into rocks and then heated deep underground. The oil and gas then seep out through porous rocks where they are collected into reservoirs and reached through down-hole drilling (wells). Geochemistry, particularly organic geochemistry tries to find if the rocks in an area are of the right sort and the right amount to form oil or gas.

Pyrolysis has been identified as the mechanism employed in the transformation of sedimentary organic matters into oil and gas. These transformations take place in a sedimentary rock usually called a ***source rock*****.** Hence the need to recognize these rocks in the early stages of petroleum exploration, for their geochemical evaluations so as determine their hydrocarbon generation potentials. The presence of more than one source rock in an area makes it more attractive. An estimate of how prolific the source has been and some indication of the nature of the hydrocarbon products (oil and gas) is valuable for effective exploration of petroleum.

For over decades now, the Niger Delta stands among the world's best studied delta complexes. Three lithostratigraphic units are recognized in the Niger Delta namely Akata, Agbada and Benin Formations (Short and Stauble, 1967). Source rock of the Niger Delta hydrocarbon has been a subject of controversy. Short and Stauble (1965) and Frankl and Cordry (1967) proposed the shale of the paralic Agbada Formation as the source rocks, while Weber and Daukoru (1975) and Ekweozor and Daukoru (1984) argued that in most parts of the delta, the Agbada Formation is immature and suggested the source rock to be the marine shale of Akata Formation which are more mature.

Hence, this research paper aims at evaluating the source rock qualities of the Agbada Formation with a view to further understand the petroleum prospects of the Niger Delta region.

2. Location of Study Area

The study area lies within the southern part of Delta state. Specifically in a riverine community in Warri North Local Government area. It is known for playing host to a prolific oil field with oil wells. Samples were recovered from an interval of an appraisal well within the study area.

Figure 1: **Map of Nigeria showing the Niger Delta Region.**

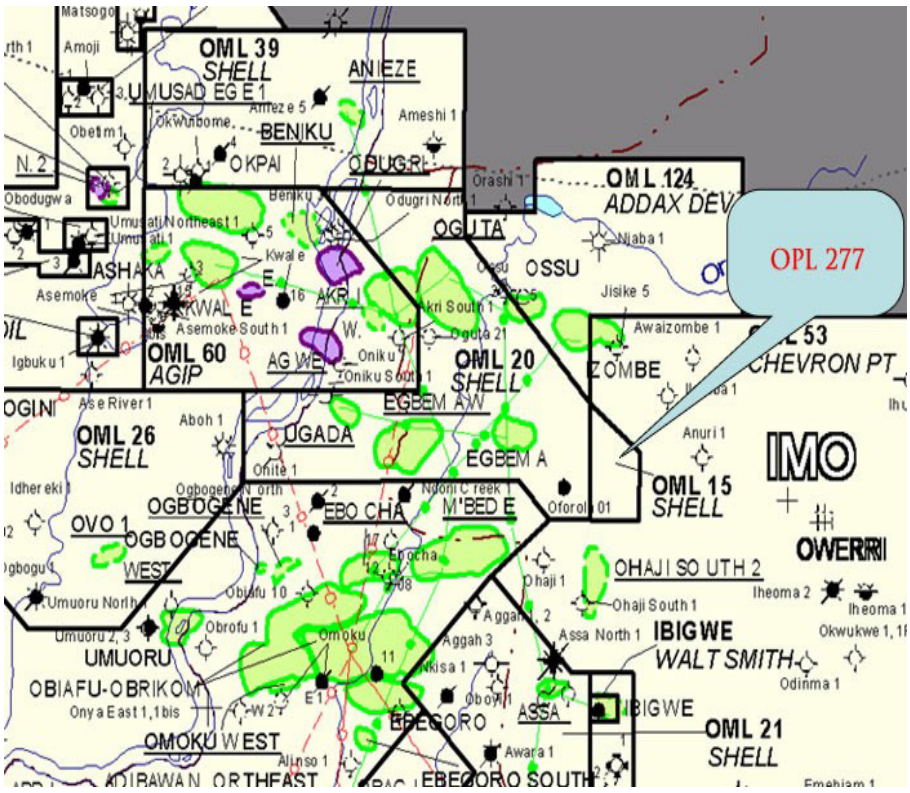

Figure 2: Niger Delta Regions showing oil wells.

3. Aim of Study

This study is aimed at carrying out the geochemical characterization of a sedimentary section from a depth slice within OML 40, in the Warri North area of the Southern Niger Delta. The characterization involves analysis and interpretation of parameters determined from sampled source rocks in order to determine the hydrocarbon source potential of the studied sediments.

4. Methodology

Sample Preparation: Selected samples from defined intervals (Table 1) in their lithologic arrangement from oldest to youngest were oven dried properly after which they were grinded individually.

Table 1: Selected Sample Interval

Sample Number	Depth interval (meters)
1.	2700 – 2800
2.	2800 – 2900
3.	2900 – 3000
4.	3000 – 3100
5.	3100 – 3200
6.	3200 – 3300
7.	3300 – 3400
8.	3400 – 3500
9.	3500 – 3600
10.	3600 – 3700

- ***Evaluation Techniques*:** All recoverable ditch-cuttings from a well in OML 40 were subjected to geochemical analysis in order to characterize their petroleum generation potentials. The analytical methods involves are:

(a) Extraction and Fractionation of soluble organic matter (SOM) from the samples and
(b) Determination of total organic carbon (TOC) content

- ***Total Organic Carbon (TOC):*** TOC determination is done to estimate the quantity of organic matter in each sample. The basic principle behind this is that organic carbon is determined by a mixture of hydrogen tetraoxosulphate (iv) acid and aqueous potassium dichromate (K2Cr2O7).After complete oxidation from the heat of solution and external heating, the unused or residual K2Cr2O7 (in oxidation) is titrated against ferrous ammonium sulphate. The used K2Cr2O7, the difference between added and residual K2Cr2O7 gives a measure of organic content of sediment.
- **Soluble Organic Matter (SOM):** In determining source rock potential, It is important to identify hydrocarbon rich sediments which can be achieved through extraction process and the determination of yield of soluble organic matter (SOM). The ratio of soluble organic matter (SOM) to the total organic carbon (TOC) gives an indication of the maturity status of hydrocarbon generative potential of the source rock.

5. Results

The total organic *carbon content* (TOC) of the ten (10) analyzed samples varied from 1.50wt% - 1.70wt%, with an average of 1.56%. Table 2, shows the end point and TOC values obtained.

Table 2 - Total organic carbon content of the study area.

S/N0	Depth Interval	End Point Values	TOC (Wt.%)	Rating
1.	2700 – 2800	1.82	1.70	Good
2.	2800 – 2900	1.85	1.57	Good
3.	2900 – 3000	1.69	1.60	Good
4.	3000 – 3100	2.15	1.50	Good
5.	3100 – 3200	2.15	1.51	Good
6.	3200 – 3300	2.13	1.51	Good
7.	3300 – 3400	1.95	1.55	Good
8.	3400 – 3500	1.92	1.56	Good
9.	3500 – 3600	1.98	1.54	Good
10.	3600 – 3700	1.95	1.55	Good

The total organic carbon content of the well samples analyzed varies from 1.50% - 1.70% with an average TOC value of 1.56wt%. These values conform to Ekwezor and Okoye (1985) TOC values for source rocks in the Agbada Formation of the Niger Delta.

Studies have shown that TOC OF 0.5% is the standard minimum threshold value for source rock to generate hydrocarbon.

Therefore an average TOC value of 1.56% for samples studied is well above the minimum threshold for hydrocarbon generation.

Philip et al (1986) confirms that the quantity of organic matter present in a rock can be evaluated and classified using the total organic carbon content as indicated below:

TOC (WT %)	**Grade of Source Rock**
< 0.5%	Poor
0.5% - 1.0%	Fair
> 1.0%	Good.

From the data above, it can be inferred that the analyzed samples which yield organic carbon values are greater than the threshold value (0.5%). The organic carbon rating of the source rock can be said to be very good.
Extractable Soluble Organic Matter *(SOM)* results obtained from subjecting samples to extractable soluble organic matter analysis (SOM) are as shown in Table 3 below.

Table 3: Soluble Organic matter test for samples obtained from well (OML 40).

S/NO	Depth	Wt. of Sample (g)	Wt.of Extract	SOM(w %)	SOM (ppm)
1.	2700-2800	20	0.1187	0.6400	6400
2.	2800-2900	20	0.0263	0.6300	6300
3.	2900-3000	20	0.0040	0.020	200
4.	3000-3100	20	0.0031	0.019	190
5.	3100-3200	20	0.0074	0.0039	390
6.	3200-3300	20	0.0038	0.022	220
7.	3300-3400	20	0.0041	0.025	250
8.	3400-3500	20	0.0020	0.013	130
9.	3500-3600	20	0.0054	0.300	300
10.	3600-3700	20	0.0010	2.850	2850

From result shown above in Table 3, the SOM values increased with the depth of burial. Studies show that soluble organic matter (SOM) content in the range of 0.15% - 3.36% is relatively high. Hence, the average SOM value for analyzed well samples fall within this range and are judged to be high.

The value of SOM ranges from 0.019% to 2.85% with an average of 0.456%. The average SOM value for analyzed well samples falls within this range, and is interpreted to be high.

- **Transformation Ratio:** The transformation ratio, which serves as a quantitative analysis is an index of maturity. It is investigated as a comparative measure between the values of SOM and those of TOC.

Table 4.Average Transformation Ratio

S/N	Depth	TOC (w%)	SOM (w%)	TR= SOM/TOC
1.	2700-2800	1.70	0.6400	0.38
2.	2800-2900	1.57	0.6300	0.40
3.	2900-3000	1.60	0.020	0.013
4.	3000-3100	1.50	0.019	0.013
5.	3100-3200	1.51	0.0039	0.003
6.	3200-3300	1.51	0.022	0.015
7.	3300-3400	1.55	0.025	0.016
8.	3400-3500	1.56	0.013	0.008
9.	3500-3600	1.54	0.300	0.19
10.	3600-3700	1.55	2.850	1.84

Average transformation ratio is 0.29
Since the standard threshold value for transformation ratio is 0.16 (Deroo et al, 1988). Results from Table 4 show average transformation ratio for samples from SOM/TOC comparative method as 0.29. This is far above the standard threshold value required for hydrocarbo0n generation. Thus, implies that the sediments are good source rocks.

6. Discussion

In this article, two criteria were used in characterizing ditch-cuttings from sampled well (OML 40) within the Agbada Formation. These include organic richness and degree of maturation.

The total organic carbon content ranges from 1.50w% - 1.70wt% with an average of 1.56%. This implies that they are very good, and fall within the range expected in the Niger Delta area (Ekweozor et al, 1984). The extractable organic matter also tends to increase as the depth of burial increases. The values obtained were interpreted to be high (SOM values of 0.019% - 2.85%, average of 0.456%).

The level of maturity of the sediments in lieu of its hydrocarbon generation potential is determined using transformation ratio. The lowest value is obtained at a depth of 3100m-3200m. Depth intervals of 2900-3000m,3000-3100m,3100m-3200m and 3400m-3500m respectively all show a low transformation ratio and hence are known for low hydrocarbon generation. Generally, the average value of TR for the studied samples exceeds this threshold. Therefore, the samples can be said to be fairly mature and hence good source rock material.

7. CONCLUSION

Results from Geochemical characterization of ditch- cuttings from sampled well (OML 40) indicates that the samples have required qualities of a good source rock.

The TOC values range from 1.50%-1.70% with an average of 1.56%. According to Bordenare et al (1993), the TOC of a sediment is the basic parameter which is required to interprete any other geochemical information obtained by other methods. Therefore, good source rocks have high TOC values. The average TOC value for the studied samples is in agreement with the 0.4-4.4% range reported by Ekweozor and Okoye (1985) for the Niger Delta source rocks.

It is generally accepted that good shaly source rock of liquid petroleum should normally have a minimum average TOC of 1- 2wt%. Therefore, it is reasonable to conclude that the sampled section has the optimum Kerogen concentration to produce petroleum. This view is reflected in the extractable soluble organic matter values. The maturity status of the sediments show a fairly good agreement with the views of Short Sand Stauble (1965), and Frankl and Cordry (1967) that the shales of the parallic Agbada Formation are source rocks in the Niger Delta.

REFERENCES

[1] **Assez, L.O.,** (1974): Review of the stratigraphy, Sedimentation and structure of the Niger delta: paper from conference on the geology of Nigeria. P. 259-272.
[2] **Allen, J.R.:** *Sedimentation in the Modern Delta of the River Niger, West Africa*. Proc. 6th Conference of Sedimentologists p. 26-34, 1963
[3] **Bordenave, E.,** Ph. Betrand, M.L., Brosse, E., Espitalie J., Houzay, J.P., Pradier B., Vandenbroucke U. and Walgenwitz F., 1993. *Geochemical methods and tools for source rock appraisal*. In Applied Petroleum Geochemistry (ed) 1993.
[4] **Cavaliere, R.:** *Source rock evaluation of the Niger basin.* Unpublished Agip report. Pp. 4 NAOC, 1978.
[5] **Deroo G.,** Herbin J.P., Roucache J. and Tissot B.,. *Organic geochemistry of some Cretaceous black shales from sites* 367 and 368, 1977.
[6] **Ejedawe J.E.** and Okoh S.U., *Prediction of Depths of Petroleum Occurrence in the Niger Delta.* Oil and Gas Jour. V. 79, p190-207, 1981
[7] **Ejedawe, J.E.,** *Pattern of Incidence of Oil reserves in the Niger Delta Basin*. Amer. Assoc. Petrol. Geol. Bull. V. 65, N0. 9 p.1574-1585, 1981
[8] **Ekweozor C.M.** and Daukoru, E.M., *Petroleum Source Bed Evaluation of the Tertiary Niger Delta.* Amer. Assoc. Petrol. Geol. Bull. V. 68, p. 390-394, 1984.
[9] **Ekweozor C.M.** and Okoye N.V., *Petroleum Source Bed Evaluation of the Tertiary Niger Delta.* Amer. Assoc. Petrol. Geol. Bull V. 64, p. 1251-1259, 1980
[10] **Evamy B.D.,** Haremboure J.W., Kameling P., Kaap W.A., Lolloy F.A. and Rowlands P.H., *Hydrocarbon Habitat of Tertiary Niger Delta.* Amer. Assoc. Pet. Geol. Bull. V. 62 p. 1-39, 1978
[11] **Frankl E.J.** and Cordry E.A., *The Niger Delta Oil Province- Recent Developments Onshore and Offshore:* Proc. 7th World Petroleum Cong. Mexico City. V. I b. p. 195-209, 1967.
[12] **Keelan, D.K. 1971**, A critical review of core analysis techniques; Journal of Canadian petroleum tech. P. 42-55.
[13] **Lambert-Aikionbare D.O.** and Ibe A.C., *Petroleum Source Bed Evaluation of Tertiary Niger Delta.* Amer.

Assoc. Petrol. Geol. Bull. V. 68 p. 387-389, 1984.
[14] **Merki J.,.** *Structural Geology of the Cenozoic Niger Delta* Sediments in Shell BP. Geol. Lab. Note N0. 391; 20Pp, 1971.
[15] **Niger Delta Environmental Survey**, Report (NDES);, Vol. 1 p. 17-84, 1997.
[16] **Porrenga, D.H.,** *Glauconites and Chamosites as Depth indicators in a Marine Environment.* Mar. Geol. V. 5 p. 495- 501, 1967.
[17] **Porrenga, D.H.,** *Chamosite in Recent sediment of the Niger and Orinoco Deltas. Geol.* En. Mijnbouw V. 44, p. 400-403, 1965.
[18] **Reyment R.A.,** *Aspects of the Geology of Nigeria.* Ibadan Univ. press, p. 1-133, 1956.
[19] **Ronov,** A.B., *Organic carbon in sedimentary rocks (in relation to presence of petroleum) Geochemistry* 5:510-536, 1958. (English translation).
[20] **Short K.C.** and Stauble A.J., *Outline of Geology of Niger Delta.* Amer. Assoc. Petrol. Geol. Bull. V. 57, p. 761-779, 1967.
[21] **Stacher, P.,** 1995. *Present understanding of the Niger Delta hydrocarbon Habitat.* In: Oti M.N. and Postma G. (eds) 1995. Geology of Deltas. A.A. Balkema Publisher, Rotterdam: 1st Edition p. 257-267.
[22] **Weber, K.J.** and Daukoru, E.M., Petroleum *Geology of the Niger Delta:* Proc. 9th World Petroleum Congress; Tokyo, V. 2, p. 202-221, 1975.
[23] **Weber, K.J.,** *Sedimentological aspects of Oil Fields in the Niger Delta:* Geologieen Mynbouw. V. 50 p. 59-576, 1971.

ABOUT THE AUTHORS

Jayeola, A.O. holds a Master of Science degree (M.Sc.) in Petroleum Geology from the University of Port Harcourt, Port Harcourt, Rivers state, Nigeria. He also holds a Bachelor of Science degree (Hons.) in Geology from Adekunle Ajasin University, Akungba Akoko, Ondo state, Nigeria. He is presently a Lecturer in the Department of Earth Sciences, Faculty of Science, Adekunle Ajasin University, Akungba Akoko, Ondo state, Nigeria. He is an active member of some local and international professional associations among which are: Nigerian Association of Petroleum Explorationists (NAPE), American Association of Petroleum Geologists (AAPG), Nigerian Mining and Geosciences Society (NMGS)

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar